



Research Range Services annual report



2008



NASA Wallops Flight Facility



This annual report is dedicated to Jim Johnson, who retired this year after 42 years of service at Wallops Flight Facility. Johnson's duties during his career included stints in the NASA Communications (NASCOM) Center and in both the Scheduling and Telemetry offices supporting such missions as Gemini, Apollo, Skylab and the Space Shuttle.

Johnson now spends his time with his family in Accomac, Virginia, and may have found a new career as a politician serving on the town's council after recently winning re-election to his seat.

contents

Executive Summary—**1**

Introduction—**2**

Program Management—**9**

Operational Missions and Accomplishments—**13**

A. NASA Science—**14**

B. NASA Space Operations—**19**

C. NASA Aeronautics—**20**

D. Department of Defense—**22**

E. Civil Agencies—**24**

Program Modernization—**27**

Outreach and Education—**34**

Looking Ahead to FY 2009 and Beyond—**37**



◀ The RRS Program established a new mobile support capability at St. Georges, Bermuda

Executive Summary

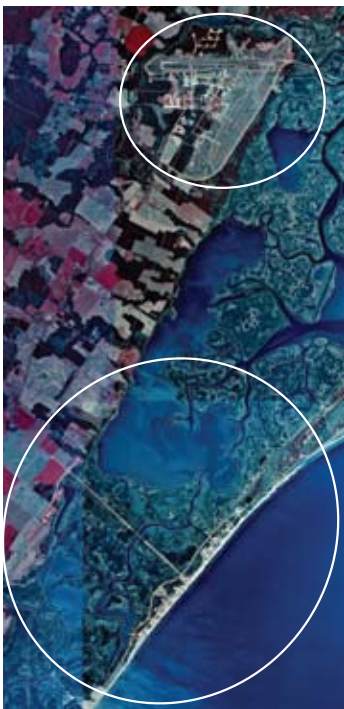
This Annual Report provides an overview of the performance of the National Aeronautics and Space Administration (NASA), Goddard Space Flight Center (GSFC), Wallops Flight Facility (WFF), Research Range Services (RRS) Program for FY 2008, the fiscal year ending September 30, 2008.

The RRS Program experienced a very productive year with support of critical NASA missions benefiting all NASA Directorates. In addition, the RRS Program provided ground instrumentation services for reimbursable missions for the Department of Defense (DoD) and other government agencies. Finally, engineers supporting RRS demonstrated significant operational and engineering improvements for the RRS Program, other ranges and NASA science missions.

The motivation and dedication of the RRS staff are what made this program so successful in FY 2008. By upholding the organization's heritage of responsiveness and innovation, they successfully supported missions world-wide while also improving RRS capabilities to support future opportunities for NASA.

Major missions supported during the year included several Sounding Rocket missions studying Sun-Earth physics, Hypersonics missions studying Boundary Layer plasma physics, offsite (mobile) campaigns to Norway, NASA's Space Shuttle support for launch, on-orbit, and landing and several DoD operations utilizing missiles, drones and Unmanned Aircraft System (UAS) vehicles. ■

▶ Satellite imagery of Wallops Flight Facility, home to the RRS Program





◀ WFF features a full-service airport with three runways and several RRS fixed telemetry and radar assets

Introduction

The RRS Program supports NASA operational and research objectives by providing tracking, telemetry, meteorological, optical, control center and command services for aerospace flight vehicles including orbital and suborbital rockets, aircraft, satellites, the Space Shuttle, balloons and UAS vehicles, providing real-time display and capture of mission-specific flight, payload and science data. While RRS support is primarily focused on NASA's Science Mission Directorate (SMD) objectives to fulfill the Agency's Strategic Goal 3B to *Understand the Sun and its effects on Earth and the solar system*, its services also contribute to additional NASA strategic goals and objectives in support of the other NASA Mission Directorates: Space Operations, Aeronautics Research and Exploration Systems. The specific NASA missions supported by the RRS Program in FY 2008 and beyond are aligned with these strategic goals.



◀ Wallops Island is where the WFF launch assets and many RRS support instrumentation are located

The Range Control Center is the heartbeat of RRS operations conducted at WFF ▶



GMT PROGRAM LIFT OFF
MELBOURNE

AZ: 20 EL: 6 AZ: 226 EL: 20

PAD-08/S BH-3

NASA
WALLOP
LIGHT FAC

RRS-Supported NASA Goals

Strategic Goal 1: Fly the Shuttle as safely as possible until its retirement, not later than 2010.

Sub-goal 1.1: Assure the safety and integrity of the Space Shuttle workforce, systems and processes, while flying the manifest.

Strategic Goal 2: Complete the International Space Station in a manner consistent with NASA's International partner commitments and the needs of human exploration.

Sub-goal 2.1: By 2010, complete assembly of the U.S. On-orbit Segment; launch International Partner elements and sparing items required to be launched by the Shuttle and provide on-orbit resources for research to support U.S. human space exploration.

Strategic Goal 3: Develop a balanced overall program of science, exploration and aeronautics consistent with the redirection of the human spaceflight program to focus on exploration.

Sub-goal 3B: Understand the Sun and its effects on Earth and the solar system.

- *3B.1: Progress in understanding the fundamental physical processes of the space environment from the Sun to Earth, to other planets and beyond to the interstellar medium.*

Sub-goal 3E: Advance knowledge in the fundamental disciplines of aeronautics and develop technologies for safer aircraft and higher capacity airspace systems.

- *3E.2: By 2016, develop and demonstrate future concepts, capabilities and technologies that will enable major increases in air traffic management effectiveness, flexibility and efficiency, while maintaining safety, to meet capacity and mobility requirements of the Next Generation Air Transportation System.*

Strategic Goal 4: Bring a new Crew Exploration Vehicle into service as soon as possible after Shuttle retirement.

Sub-goal 4.1: No later than 2014, and as early as 2010, transport three crewmembers to the International Space Station and return them safely to Earth, demonstrating an operational capability to support human exploration missions.

RRS Mission Support	NASA Strategic Sub-goals				
	1.1	2.1	3B.1*	3E.2	4.1
FY 2008					
Mid Latitude Spread F			◆		
Mesquito Launch Vehicle #1			◆		
Mesquito Launch Vehicle #2			◆		
RockOn!			◆		
Suborbital Technology Experiment Carrier II (Sub-TEC II)			◆		
Twin Rockets to Investigate Cusp Electrodynamics (TRICE)			◆		
Sounding of the Cusp Ion Fountain Energization Region-II (SCIFER-II)			◆		
Space Shuttle	◆	◆			
Hypersonic Boundary Layer Transition, Sub-Orbital Aerodynamic Re-entry Experiments, ATK Launch Vehicle (HyBOLT SOAREX ALV)				◆	
Generic Transport Model, Airborne Sub-scale Transport Aircraft Research (GTM AirSTAR)				◆	
Unmanned Aircraft System (UAS) Hurricane			◆		
AeroScience Laboratory			◆		
FY 2009 and Beyond					
Poker Sounding Rocket Campaign:					
Aurora Current and Electrodynamics (ACES) Launch Vehicle #1			◆		
ACES Launch Vehicle #2			◆		
Ionospheric Science and Inertial Sensing (ISIS)			◆		
Changing Aurora in-situ and Camera Analysis of Dynamic Electron Precipitation Structure (CASCADES 2)			◆		
Turbopause Launch Vehicle #1			◆		
Turbopause Launch Vehicle #2			◆		
Turbopause Launch Vehicle #3			◆		
Turbopause Launch Vehicle #4			◆		
Max Launch Abort System (MLAS)					◆
Ares 1-X and 1-Y					◆
Lunar Atmosphere and Dust Environment Explorer (LADEE)			◆		
GTM AirSTAR				◆	
UAS Hurricane			◆		
AeroScience Laboratory			◆		
Mesquito Launch Vehicle #3			◆		
Mesquito Launch Vehicle #4			◆		
Mesquito Launch Vehicle #5			◆		
Mesquito Launch Vehicle #6			◆		
Terrier Malemute Test Flight			◆		
RockOn!			◆		
SOAREX			◆		
Ceramics Analysis and Reliability Evaluation of Structures (CARES)			◆		
Sub-TEC III			◆		
Inflatable Re- Entry Vehicle Experiment (IRVE II)				◆	
Rocket Experiment for Neutral Upwelling (RENU)			◆		
Correlation of High-Frequencies and Auroral Roar Measurements-2 (CHARM-2)			◆		
Polar Night Nitric Oxide (Polar NOx)			◆		
Trimethyl Aluminum Ampule (TMA Ampule)			◆		
Pharmasat			◆		

The RRS Program has the capability to support users requiring concurrent operations with dedicated instrumentation for each flight vehicle, redundant range instrumentation coverage, spatial diversity and information assurance, a variety of viewing angles for optical instruments and flexibility and adaptability through use of deployable mobile assets. The RRS Program offers a dozen specific services that can be tailored individually or collectively to NASA customers, DoD and other federal agencies, international space agencies, universities and the aeronautical industry.

Within these service offerings, the RRS staff operates, maintains and provides a wide variety of facilities and capabilities that are essential to enable and ensure the success of each mission:

- Fixed and mobile radar systems for tracking of launch vehicles, satellites and aircraft; ground-based and airborne radars for area surveillance to provide weather measurements and ensure safety during flight operations.
- Fixed and mobile telemetry antennas, receivers and display systems to gather and provide information from flight vehicle and payload instrumentation during pre-launch checkout and during flight mission operations.

- Voice, video and data communications systems for control and coordination of operational missions.
- Data systems to acquire, record and display information in real time for control and monitoring of flight vehicle performance.
- Optical and television facilities to provide and archive still photography, printing, aerial photography, fixed and mobile tracking and instrumentation camera coverage.
- Fixed and mobile command systems to control flight vehicles and provide flight termination capabilities for range safety purposes.
- Frequency spectrum allocation management and coordination capabilities and monitoring equipment to detect and locate sources of interference.
- Master timing station to synchronize range activities and data.
- Range Control Center (RCC) to coordinate and monitor mission operations, flight vehicles and payload instrumentation during operations.
- Meteorological instrumentation to measure and display atmospheric data, ionosphere characteristics and weather conditions.



The RRS Program offers a dozen specific services that can be tailored to customer requirements



▲ This year, RRS staff and equipment traveled to locations around the globe to provide range services

Research Range Services personnel perform a variety of important tasks leading up to a mission. WFF representatives confer with prospective new range users to understand their mission and determine whether it will be feasible, including RRS support capability. If so, WFF then provides a letter of approval to identify the project manager, any applicable conditions on RRS support and the estimated project support cost. The RRS staff works closely with project managers to assist in developing documentation to describe the specific range support that will be required and discuss all safety-related and flight trajectory information and procedures. Research Range Services personnel also conduct pre-mission reviews for each project to ensure all preparations are complete before flight and everyone involved understands the operational details and their roles and responsibilities. Following the mission, RRS personnel conduct

a post-operation meeting to evaluate the operation and identify any items requiring future action.

While Wallops is the prime location for RRS support, major sounding rocket campaigns have been supported at Poker Flat, Alaska; Andoya, Norway; St. Georges, Bermuda and Kwajalein Island, Marshall Islands, requiring RRS staff and equipment to travel to some of the most remote locations on Earth to either supplement instrumentation at existing ranges or to establish a site with temporary range services. ■



Foreground: John Kamps, RRS Photo/Optical Lab technician, operates the Intermediate Focal Length Tracker. This mobile unit can be configured with various video cameras and lenses

Program Management

Overview

The staff at NASA Headquarters is responsible for determining overall Agency research range services direction and content through the strategic planning and budget formulation process. The RRS Program Office within the SMD Heliophysics Division provides policy and direction in accordance with NASA Procedural Requirements 7120.8 to ensure RRS activities and investments support the broader Agency priorities.

Program Management Overview	
Directorate	Science Mission Directorate
Division	Heliophysics
Program Executive	Ms. Cheryl Yuhas
Program Manager	Mr. Jay Pittman
Lead Center	Goddard Space Flight Center
Performing Center	GSFC Wallops Flight Facility
Program Type	Research Range Services

Using a balanced approach of managed capacity and cost recovery, the RRS Program Manager was responsible in FY 2008 for providing launch instrumentation support for NASA sub-orbital programs and projects while simultaneously enabling a major remote campaign and a Wallops mission involving local launch sites and a downrange deployed tracking/command site.

To accomplish these goals and to support additional customers, the RRS staff met the following mission requirements:

- Proficiently operated all range instrumentation to satisfy all mission requirements through operator certification, configuration management, pre-mission testing and approved operational procedures.
- Assured range instrumentation was available for all missions through mission planning and effective corrective and preventive maintenance.
- Utilized systems sustainment, engineering and technology advancements to meet new mission requirements, improve range safety, reduce operational costs and replace obsolete equipment.

The RRS Program Manager was also responsible for overseeing the technical performance of contract services including setting mission priorities, ensuring sufficient staffing levels, identifying and prioritizing engineering upgrades and overseeing efforts between NASA engineering and contractor personnel.

Resources

The FY 2008 RRS Program included valuable resources in both staffing and inventory. Using the Program’s budget of \$17.37 Million for operations, engineering and logistics, the staff of 119 civil service and contractors was responsible for more than \$231 Million in fixed and deployable mobile instrumentation and state-of-the art communications and support equipment. ■

RRS Staffing

Civil Service: 10
RRS Program Manager
Deputy Program Manager
Chief Engineer
Financial Manager
Contract Support
Systems Engineers (5)

Contractor: 109
Management and Engineering (36)
Radar Services (27)
Telecom Services (23)
Meteorological Services (8)
Video and Optical Services (8)
Range Control (7)

These command antennas are used by RRS to send guidance and, if needed, destruct commands to vehicles launched at WFF. They also support command and voice operations for Space Shuttle missions



RRS Assets: \$231.6 (in millions)

Telemetry Systems: \$29.2	Per Unit	Qty	Total
7.3-meter Fixed Antenna	\$1.5	2	\$3.0
7-meter Mobile Antenna	\$1.5	2	\$3.0
Mobile Telemetry Van	\$1.5	1	\$1.5
20-foot Mobile System	\$2.0	1	\$2.0
Mobile Super Van	\$2.5	1	\$2.5
10-foot Mobile Antenna	\$0.5	1	\$0.5
8-foot System	\$0.4	2	\$0.8
8-foot Mobile Antenna	\$0.4	1	\$0.4
8-meter Antenna	\$2.5	2	\$5.0
16-foot System	\$0.5	1	\$0.5
9-meter Redstone	\$6.0	1	\$6.0
9-meter System	\$4.0	1	\$4.0

Atmospheric Radars: \$48.0	Per Unit	Qty	Total
Space Range Radar	\$20.0	1	\$20.0
Ultra High Frequency (UHF)	\$18.0	1	\$18.0
S-band Weather (Tropical Ocean Global Atmosphere)	\$5.0	1	\$5.0
NASA Polarimetric (NPOL)	\$5.0	1	\$5.0

Tracking Radars: \$108	Per Unit	Qty	Total
Range Instrumentation Radar-778C	\$6.0	4	\$24.0
Range Instrumentation Radar-716	\$7.0	2	\$14.0
Range Instrumentation Radar-706	\$70.0	1	\$70.0



RRS Radar 3 at WFF

These RRS atmospheric science radars are used to collect cloud moisture composition and density data

Surveillance Radars: \$13.9	Per Unit	Qty	Total
Airport Surveillance Radar-7	\$10.0	1	\$10.0
Pathfinder	\$0.7	2	\$1.4
Active Protective System-143	\$2.5	1	\$2.5

Range Safety Systems: \$31.3	Per Unit	Qty	Total
Fixed UHF Command System	\$4.0	1	\$4.0
Mobile Command System	\$1.4	1	\$1.4
Mobile Range Control System	\$2.1	1	\$2.1
Radio Frequency Communication	\$3.0	1	\$3.0
Timing System	\$0.8	1	\$0.8
Control Center	\$10.0	1	\$10.0
Video & Optical Systems	\$10.0	1	\$10.0

Mobile Power: \$1.2	Per Unit	Qty	Total
Mobile Power Systems	\$0.3	4	\$1.2



Radar 5 is the RRS Program's most powerful tracking asset

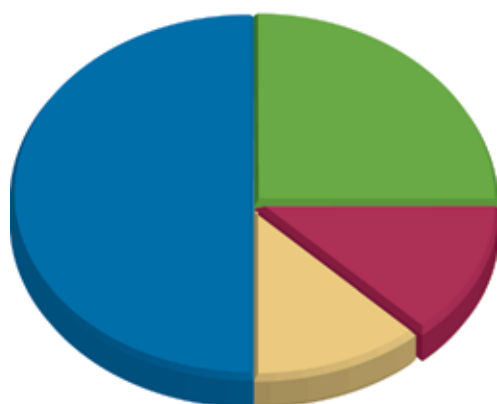




Gary Thomas, RRS mobile telemetry leader, assembles a mobile 7-meter antenna at Andoya, Norway

Operational Missions and Accomplishments

RRS Customer Distribution



- Science: 50%
- Space Operations: 25%
- Exploration Systems: 12.5%
- Aeronautics Research: 12.5%

The customer base for the RRS Program includes a variety of NASA programs and spans all four Mission Directorates (Science 50%, Space Operations 25%, Aeronautics Research 12.5% and Exploration Systems 12.5%). The Program enables and supports the safe and successful execution of the Agency's Sounding Rocket, Space Shuttle and UAS programs through critical involvement of RRS fixed and mobile range assets, services and capabilities at WFF and remote locations. The RRS staff maintains partnerships and actively coordinates with a number of other federal and local government agencies to plan and conduct these operations.

The RRS Program also supports DoD and civil agency programs and missions. In supporting these activities, the staff works closely with a diverse group of customers and successfully collaborates with the U.S. Navy, the Missile Defense Agency (MDA), the National Weather Service (NWS), the National Oceanic and Atmospheric Administration (NOAA) and others.

NASA Science

In FY 2008, the RRS Program provided a variety of essential planning, coordination and technical services to enable and support eight launches of SMD research payloads using five different types of sounding rocket vehicles flying from WFF and, using the RRS mobile range assets, from Andoya Rocket Range (ARR), Norway. These missions contributed to NASA's Strategic Goal 3 to *"Develop a balanced overall program of science, exploration and aeronautics consistent with redirection of the human spaceflight program to focus on exploration"* and Sub-Goal 3 B.1 to both *"Understand the Sun and its effects on Earth and the solar system"* and *"Progress in understanding the fundamental physical processes of the space environment from the Sun to Earth, to other planets and beyond to the interstellar medium."*

Wallops Flight Facility

Mid Latitude Spread F

In support of the Sounding Rocket Program, the RRS Program supported the successful launch of a Terrier-Black Brant sounding rocket carrying a 657-pound payload in October 2007. The Mid Latitude Spread F mission built on previous science work using data collected during sounding rocket flights from WFF to investigate mid-latitude ionospheric irregularities associated with terrestrial weather systems. The flight used a two-part payload to study ion density depletions in the F-region of the upper atmosphere as a result of electrical fields that form in response to plasma motion. The F-region is the uppermost layer of the ionosphere, more than 100 miles above the Earth's surface.

Research Range Services personnel worked smoothly through the detailed planning, coordination and safety approval processes to identify, schedule and coordinate use of launch range assets to support this mission with only a few days left in the available launch window. In preparation for the mission, RRS meteorologists monitored the location and motion of low pressure systems in the area to determine when suitable conditions were in place for the phenomenon that the science mission was designed to investigate and measure.

During countdown, launch and flight, RRS staff actively coordinated and monitored all aspects of range support—tracking, telemetry data collection, tracking cameras and video systems, communications and timing, range surveillance and flight control—through the RCC. The staff also coordinated and provided use of authorized operating space over the Atlantic Ocean so the payload instruments could collect scientific data during the mission and arranged for the appropriate frequency spectrum to enable the payload to transmit the science data to the ground. In addition, the RRS Program provided



Mid Latitude Spread F mission prepared for launch at WFF



Debbie Stanley, RCC Supervisor, works with Jimmy Holloway and Cleveland Chandler during operations at WFF

ground-based instrumentation, high frequency radar and scintillation receivers to collect science data about the layers of the upper atmosphere and provide details regarding electron content along the flight path and information on gravity wave propagation from lower layers of the atmosphere into the upper atmosphere.

For more information: Ron Walsh, ronald.b.walsh@nasa.gov

Mesquito

In May 2008, the RRS Program planned and coordinated range support to enable two back-to-back development test flights of a new design for a two-stage rocket called Mesquito. NASA's Sounding Rocket Program is developing the Mesquito rocket using military surplus Multiple Rocket Launch System rocket motors to demonstrate that it can be manufactured and launched at 20% of the cost of a comparable Orion sounding rocket launch. The test phase is intended to ensure Mesquito is a safe, reliable vehicle for mesospheric research missions.

Mesquito consists of a 9-inch diameter solid propellant rocket motor as the first stage booster and a non-propulsive second-stage dart designed to accommodate an experiment section and other systems to provide rocket-borne measurements of the mesospheric region of the upper atmosphere. The mesosphere is the layer of the Earth's atmosphere between the stratosphere and the thermosphere, about 35 to 50 miles above the Earth's surface where the coldest region of the atmosphere is found. The mesosphere can only be reached by using sounding rockets because it is above the highest altitude that can be reached by aircraft and below the minimum altitude where spacecraft can orbit the Earth.

This use of NASA's Wallops Research Range as a *Test Range* is a unique capability and one which is growing in popularity with the emergence of the Exploration Systems Mission Directorate program to flight test key components and mission elements.

Research Range Services radars tracked the boosters for both Mesquito test flights to provide performance data but were unable to acquire the dart on the second mission due to an anomalous flight trajectory. Data from both flights will contribute to the continuing development of the new vehicle.

For more information: Ron Walsh, ronald.b.walsh@nasa.gov



Two-stage Mesquito Sounding Rocket with Dart prior to launch

RockOn!

In June 2008, the RRS Program supported a week-long Sounding Rocket Program Office outreach effort called “RockOn!” to provide 60 university faculty and students from 22 states and Puerto Rico with hands-on experience building experiments for flight on a sub-orbital rocket and learning about the steps and procedures for creating spaceflight payloads. Teams built experiment packages that included a Geiger counter and sensors for measuring temperature, acceleration and pressure, and the packages were then stacked into payload cans for launch.

Research Range Services personnel were instrumental in the culmination of the week’s learning experience, supporting the successful launch of these experiments to an altitude of 41 miles aboard a NASA single-stage Improved-Orion sounding rocket. The RRS support for the mission included weather forecasting and measurements, airborne and surface surveillance radar, fixed radar, tracking cameras and video systems, communications and timing services.

The “RockOn!” teams conducted preliminary analysis of the data collected by RRS staff after payload recovery and will work to make flight experiments a part of the educational process at their home institutions.

For more information: Ron Walsh, ronald.h.walsh@nasa.gov

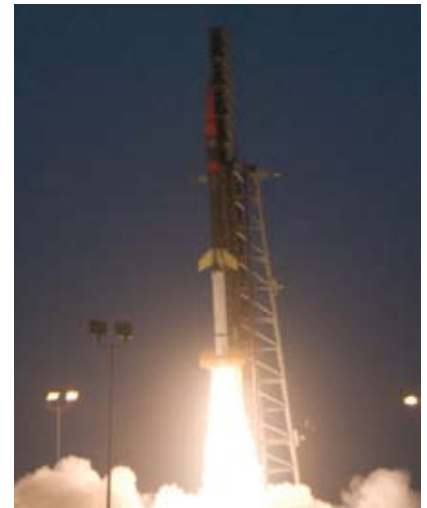


▲ RockOn! participants

Suborbital Technology Experiment Carrier II (Sub-TEC II)

In July 2008, the RRS Program supported the Sub-TEC II launch. The Sub-TEC missions are designed to provide opportunities for multiple experiments and organizations to share a ride, and seven different organizations, internal and external to NASA, participated in this year’s mission which flew aboard a NASA Terrier Mk70 Improved-Orion sounding rocket.

The purpose of the mission was to demonstrate new technologies for flight vehicle tracking, data processing, payload positioning, power and communication systems by testing their performance during an actual rocket flight. The value of these technologies will be realized



▲ Sub-TEC II launch

if they are integrated into future suborbital and orbital rockets and payloads, thus improving NASA’s capabilities for conducting science missions.

The RRS Program supported this flight by coordinating use of launch range assets and arranging for the frequency spectrum to enable the experimental payloads on board to transmit data to the ground and through satellite systems. The staff also provided tracking, telemetry data collection and flight control during the flight mission, and actively coordinated and monitored all range support, as well as flight vehicle and payload operations, through the RCC during the countdown, launch and flight.

For more information: Ron Walsh, ronald.h.walsh@nasa.gov

AeroScience Laboratory

With support from RRS meteorological services, NASA's AeroScience Laboratory conducted a "Sensors with Wings" operation in March 2008 with a prototype ImageAireLite ii UAS. This UAS is an electric powered, radio controlled, line-of-sight system weighing approximately 6.5 pounds and includes a four-camera remote sensing system and in-situ sensors. The imaging system, comprised of visible, thermal infrared and near-infrared nadir cameras as well as a forward-viewing camera with GPS information overlay, is intended for coastal, environmental and agricultural observations and is being developed for a variety of airborne platforms. The in-situ payload measures temperature, humidity and pressure and supports prototype testing of new sensors to measure elements such as carbon dioxide and sulfur dioxide. The test was specifically focused on evaluation of a four-band telemetry link to provide real-time imagery from all cameras and provided valuable guidance for further development of this compact airborne system.



ImageAireLite ii flight at WFF

The Laboratory also continued weekly Airborne Testing of Meteorological Observations Systems flight profiles with RRS meteorological aerostats (tethered balloons) and conducted a test of a new Cloud Water Content Sensor under development by Anasphere Inc. with support from the NASA Small Business Innovative Research program to provide critical feedback for sensor and data system refinement.

For more information: *Geoffrey Bland, geoffrey.l.bland@nasa.gov*

Norway's Andoya Rocket Range (ARR)

In support of the Sounding Rocket Program, the RRS Program supported two technically challenging sounding rocket missions from the ARR this year. To facilitate this support, RRS personnel transported two of its mobile telemetry antennas, a telemetry data processing trailer and mobile power system by sea to ARR. Additionally, because the rockets flew high and beyond the field of view from the fixed-location ground-based telemetry antennas at ARR, RRS personnel air-freighted telemetry equipment from WFF to the downrange site at the Svalbard Ground Station at Longyearbyen, Norway, to capture the required telemetry data from the scientific payloads

during flight. Research Range Services technicians configured the racks of receiving and recording equipment, tested the configuration at Wallops and shipped the systems to Svalbard.

This was the first time such a complex mission was attempted using a configuration of resources from both ARR and Wallops. The RRS staff worked with the Norwegian technicians to de-conflict Svalbard's very busy orbital support schedule, integrate the mobile range systems and develop the concept of operations to track and record vehicle telemetry during these challenging missions.

Twin Rockets to Investigate Cusp Electrodynamics (TRICE)

In December 2007, RRS mobile range assets, integrated with ARR assets, successfully supported the flights of two Black Brant XII sounding rockets (TRICE-High and TRICE-Low) launched within two minutes of each other. Both rockets carried similarly instrumented payloads and flew in close proximity to the same magnetic field line separated in time by four minutes and by 750 kilometers in altitude. This was the first near-simultaneous launch of two Black Brant XII four stage rockets ever conducted by the NASA Sounding Rocket Program and a particularly challenging scenario for the RRS staff to support in conjunction with ARR. The successful support of these missions was only possible due to the continuous improvements introduced by RRS engineering and maintenance personnel on these rugged mobile systems.

Magnetic reconnection is of interest in various science topics, from nuclear fusion studies on Earth to astrophysics, and the purpose of the TRICE mission was to study the phenomenon of magnetic reconnection by making high-resolution measurements in a near-Earth space plasma environment called the cusp. The cusp is the region where the Earth's magnetic field lines are most recently connected to the solar wind and where plasma can directly enter the magnetosphere. Reconnection in the Earth's near-space environment occurs when Earth's magnetic field lines, normally stretched from the Northern to the Southern hemisphere, are broken and reconnected to the Interplanetary Magnetic Field. By ensuring RRS capabilities to support complex missions involving multiple flight components, it was possible to fly two rockets through the cusp region and enable researchers to distinguish and study the signatures of spatially varying versus temporally varying reconnection events.

For more information:

Ron Walsh, ronald.h.walsh@nasa.gov

Sounding of the Cusp Ion Fountain Energization Region-II (SCIFER-II)

In January 2008, RRS personnel again returned to Norway to operate mobile telemetry systems to successfully support the flight of a NASA Black Brant XII sounding rocket from ARR carrying the SCIFER-II payload. The mission examined ionospheric outflows between 200 kilometers and 1,400 kilometers altitude in the polar cusp, gathered significant science data and set an altitude record for a Black Brant XII by reaching an apogee of about 1,460 kilometers, seven kilometers higher than SCIFER-1 which set the previous altitude record in 1995. The flight through the ion fountain energization region allowed scientists to closely observe the source of the fountain and investigate how solar wind energy is converted into plasma flow.

Telemetry antennas including five at Andoya and two at Svalbard tracked and received data from the SCIFER-II payload. The flight was observable from most of northern Norway, creating a fantastic lightshow when the exhaust from the upper stages was illuminated by the sun.

For more information: Ron Walsh, ronald.h.walsh@nasa.gov



SCIFER-II launch from Andoya, with fixed ground-based range instrumentation in foreground

NASA Space Operations

As an integral member of the Space Shuttle mission operations team, the RRS Program tracks the Space Shuttle and provides UHF ground-to-air voice communications during ascent to orbit for all of the Space Shuttle missions to the International Space Station (ISS). This RRS support primarily fulfills NASA Strategic Goal 1 to *“Fly the Shuttle as safely as possible until its retirement, not later than 2010”* and Sub-Goal 1.1 to *“Assure the safety and integrity of the Space Shuttle workforce, systems and processes while flying the manifest,”* however RRS operations also support NASA Strategic Goal 2 to *“Complete the International Space Station in a manner consistent with NASA’s International partner commitments and the needs of human exploration”* and Sub-Goal 2.1 *“By 2010, complete assembly of the U.S. On-orbit Segment, launch International Partner elements and sparing items required to be launched by the Shuttle; and provide on-orbit resources for research to support U.S. human space exploration.”*

Space Shuttle Support

In FY 2008, the RRS Program tracked more than 600 orbital passes during four Space Shuttle missions including STS-120 (October 23 – November 7, 2007), STS-122 (February 7 – 20, 2008), STS-123 (March 11 – 26, 2008) and STS-124 (May 31 – June 14, 2008). The three fixed RRS radars at WFF supported each Space Shuttle launch and ISS rendezvous, then continued to provide on-orbit tracking throughout the remainder of the missions. The telemetry systems provided backup telemetry receiving and recording during launch.

Without this tracking support provided by RRS personnel, the Space Shuttle mission control team would not have an independent tracking source to confirm the on-board guidance data, evaluate launch performance and make abort determinations during the final minutes of ascent. During on-orbit operations, RRS staff collects about half of the tracking data NASA uses to plan ISS rendezvous operations.

For more information:

Rob Hurley, robert.k.hurley@nasa.gov



◀ NASA's Space Shuttle preparing to rendezvous with the International Space Station

NASA Aeronautics

In FY 2008, the RRS Program provided essential services enabling NASA aeronautics research missions using two different types of flight vehicles, including one sounding rocket flight to propel a hypersonic flight vehicle. These activities support NASA's Strategic Goal 3 to *"Develop a balanced overall program of science, exploration and aeronautics consistent with the redirection of the human spaceflight program to focus on exploration"* and Sub-Goal 3 E.2 to both *"Advance knowledge in the fundamental disciplines of aeronautics and develop technologies for safer aircraft and higher capacity airspace systems"* and *"By 2016, develop and demonstrate future concepts, capabilities and technologies that will enable major increases in air traffic management effectiveness, flexibility and efficiency while maintaining safety, to meet capacity and mobility requirements of the Next Generation Air Transportation System."*

HyBOLT SOAREX ALV X-1 (HSA)

The HSA mission consisted of two NASA experiments integrated into a "first-flight" commercial launch vehicle called "ATK Launch Vehicle" or ALV. This collaboration allowed NASA the chance to take advantage of a free launch and flight opportunity in exchange for accepting the risks of vehicle failure associated with flying an unproven launch vehicle. Such missions are within the scope of RRS

investigation into the performance of the range and safety systems revealed no contributing factors and commended RRS elements on their support for the mission.

The two NASA payloads aboard the ALV were the Hypersonic Boundary Layer Transition (HyBOLT) experiment and the Sub-Orbital Aerodynamic Re-entry Experiments (SOAREX).

- HyBOLT was designed to pierce the atmosphere to assess the boundary layer, a very thin layer of air that flows smoothly over the surface of a vehicle in hypersonic flight conditions.
- SOAREX consisted of two NASA probes and a probe designed by the U.S. Naval Research Laboratory to assess the flight characteristics of a new self-orienting reentry vehicle shape that would allow additional volume for instruments. The SOAREX probes were also configured to test an automatic identification system and measure atmospheric conditions during flight.



support because Wallops is frequently called upon to act as a true *Test Range* in addition to its operational mission. In the early morning hours of August 22, 2008, the ALV was launched from WFF but deviated from its planned flight path. The most critical RRS component, the

HyBOLT, SOAREX, ALV X-1 sits on the Mid-Atlantic Regional Spaceport launch pad in June 2008 shortly before launch

Flight Termination Command System, was then activated to ensure public safety. While disappointing to all involved, the execution of a flight termination action is what allowed RRS personnel to prevent the errant vehicle from impacting in a populated area. A subsequent

During the mission, the ALV was to reach an altitude of more than 200 nautical miles and stay aloft for approximately 10 minutes. The anomaly that caused the failure occurred approximately 21 seconds into flight and is still under investigation.

For more information: Ron Walsh, ronald.b.walsh@nasa.gov

Generic Transport Model (GTM) Airborne Sub-scale Transport Aircraft Research (AirSTAR)

This year, the RRS Program continued to provide operational support to the GTM AirSTAR program managed by NASA's Langley Research Center near Norfolk, Virginia. The program includes a jet-powered UAS with an associated ground-based control system to investigate flight characteristics of large transport aircraft during extreme flying conditions. This program contributes to objectives of NASA's Aviation Safety Program by conducting research to address advances in vehicle health monitoring and flight controls technology. The re-



search is intended to provide resilient control for transport airplanes under adverse conditions such as post-stall flight, sensor faults, flight con-



S2 GTM AirSTAR aircraft flown at WFF in 2008

trol failure and airframe damage. The AirSTAR program was developed to conduct this research using unmanned dynamically scaled models of a commercial transport airplane in a safer environment because such flight conditions are extreme and unsuitable for full-scale manned transport airplane flight tests.

Usable airspace is often difficult to find in the busy airways surrounding the Norfolk area, thus WFF offers the best location for AirSTAR flights by providing use of its restricted airspace and a 1,500-foot UAS runway on the shore of the Atlantic Ocean. Research Range Services support included meteorological and other range assets including optical tracking to provide real-time video of mission operations.

The AirSTAR S2 L1011 model flown at WFF in September 2008 is a commercial-off-the-shelf airframe that is utilized for research flights and checkout of equipment and procedures. It weighs less than 50

pounds and is powered by a single turbine engine located in the tail of the airplane. This model, with a wingspan of 85 inches and a fuselage length of 86 inches, is 30 inches high and carries a complete research flight instrumentation package that allows control from both a range safety officer and a research pilot during flight.

Several important research results were gathered during the S2 flights this year including:

- **Virtual Airspeed Sensor:** This virtual sensor uses a simple aerodynamic lift model and accurately estimated velocity within two knots during flight.
- **In-flight Airspeed Calibration Method:** Specific flight patterns used Global Positioning Satellite (GPS) ground-speed data to calibrate onboard pitot-static based airspeed measurements.
- **Use of Automated Perturbations During Stalls:** Optimized inputs were applied to the control surfaces of the S2 during stall maneuvers in cruise and powered approach conditions to validate the accuracy of large-envelope aerodynamic models.
- **Investigation of Effect of Wavetrain Amplitude and Duration on Parameter Estimates:** S2 missions allowed research into the necessary excitation of the control surfaces to validate the accuracy and practical use of real-time dynamic models in flight.

RRS will support AirSTAR missions in 2009 using the T2 aircraft which is a 5.5% dynamically scaled version of a Generic Transport Aircraft powered by twin turbine engines designed to conduct flight dynamics and control system experiments.

For more information: *Alice Rew, alice.d.rew@nasa.gov*



The Aeronautical Control Center is where UAS flight operations are controlled at WFF



Department of Defense

The RRS Program plays a crucial role in many development and operational test programs for a variety of DoD systems. The Program also offers compatibility with DoD Major Range and Test Facility Base ranges through participation in the Range Commanders Council and voluntary compliance with Inter-Range Instrumentation Group standards, enabling RRS personnel to function in cooperative lead-range/support-range roles with DoD ranges. DoD missions are conducted on a complete reimbursable basis and within the context of a “NASA has first priority” framework that preserves NASA’s authority at WFF. Additional RRS capabilities funded by non-NASA customers are usually retained by the WFF and thereby benefit subsequent NASA missions at much reduced, if not eliminated, development costs.

Aerial Targets

When a new ship defense system is installed on a U.S. Navy Carrier, Cruiser or Destroyer, the system must be tested. Tests include firing rocket-assisted aerial target drones against a test ship and the test ship’s Standard Missile or on-board computer-controlled guns engaged to shoot down the drones. Wallops Flight Facility is the only east coast location capable of conducting these tests, and two such exercises were conducted this year. One of those exercises provided the USS San Antonio a final assurance that its onboard systems were ready for the crew’s subsequent overseas mission. The RRS Program provided three tracking radars, two telemetry systems for challenging over-the-horizon communications, meteorological and photo optical support. When the target drones were successfully destroyed by the USS San Antonio off the coast of Virginia, the sound of sailors cheering filled the intercom at the RCC.

For more information: Rob Hurley, robert.k.hurley@nasa.gov

Missile Exercise

WFF has been supporting the Navy’s Missile Exercise project since 1992, and the most recent operation in December 2007 again demonstrated how the RRS Program enables DoD combat and space objectives. In these exercises, the Navy demonstrated safe separation of multiple types of missiles from a variety of wing stations from different types of aircraft. Two aircraft from the Naval Air Warfare Center, Aircraft Division at Patuxent River, Maryland, participated in the December test with one aircraft launching the missiles and the

▼ Target missile drones being fired from WFF



▲ Navy ships firing Standard Missiles at target drones

other providing photographic coverage. The RRS Program provided project support, two radars, surveillance radar, two telemetry systems, communications and frequency monitoring.

For more information: Rob Hurley, robert.k.hurley@nasa.gov

Advanced Modular Gun (AMG)

Defense Department programs require gun systems capable of firing projectiles at ever-increasing velocities and distances, and WFF is the perfect site for extended long-range testing of these systems since it routinely launches sub-orbital rockets that impact in the Atlantic Ocean as far as 500 nautical miles downrange.

The Navy completed a successful AMG test this year that saw successful firings of its 5-inch naval gun as far as 86 miles to altitudes of 155,000 feet using projectile flight pressures of more than 100,000 pounds per square inch. The distance was measured by RRS tracking systems, and results indicated a new record may have been set for distance of a gun-launched projectile. Additional RRS support included two tracking radars, two telemetry systems, meteorological and photo optical services.

For more information: Rob Hurley, robert.k.hurley@nasa.gov



▲ The AMG being fired at WFF



▲ RRS high speed digital cameras were used to monitor the NGSP Sounding Rocket launch and provided this close up of the rocket flying through an environmental stabilization box that protects the payload prior to launch

Next Generation Sensor Producibility (NGSP)

On June 26, 2008, the RRS Program provided range operations services for the successful launch of a Black Brant XI Sounding Rocket carrying the NGSP experiment for the Missile Defense Agency. The objective of this important DoD mission was to test seeker technology and improve mission assurance of sensor flight-test experiments. The launch lifted the payload into the exo-atmosphere and enabled successful demonstration of telescopes, visible and infrared sensors and a high rate Ku-band telemetry link. The Ku-band link broke new ground in Sounding Rocket technology by providing a 200 million bits per second (Mbps) telemetry downlink. Research Range Services personnel developed both the on-board electronics and the ground terminal to meet this very high data-rate requirement, providing MDA with continuous real-time images during the entire flight. This new 200 Mbps capability remains a permanent part of RRS capabilities and is available to support future NASA science missions. The RRS staff also provided radar, telemetry, range control center, surveillance, meteorological and optical services.

For more information: Doug Voss, douglas.g.voss@nasa.gov

Civil Agencies

The RRS Program supported several Civil Agencies during FY 2008 in a variety of weather and aviation missions. The long-standing relationship between the Program and both the National Weather Service (NWS) and the National Oceanic and Atmospheric Administration (NOAA) yielded important meteorological data for scientists, additional RRS customers and the public. Additionally, the continued hosting by RRS staff of the annual Runway Friction Workshop enabled future benefits to aviation flight safety measures.

National Weather Service (NWS) Support

The RRS Program has been supporting the NWS for more than four decades by launching twice daily balloon-borne radiosondes and launching unscheduled balloons in times of severe weather which are essential to the NWS forecasts for the mid-Atlantic region. This year, RRS personnel provided weather balloon launches during Tropical Storm Hanna and during other periods of severe weather and nor'easters.

Accurately predicting changes in the atmosphere requires adequate observations of the upper atmosphere, and the NWS radiosonde network is the primary source of upper-air data. The balloon-borne radiosonde network is used to simultaneously measure and transmit meteorological data while ascending through the atmosphere. The radiosonde instrument consists of sensors to measure pressure, temperature and relative humidity. NWS meteorologists analyze individual radiosonde soundings to prepare short-term local weather forecasts. Individual soundings help forecasters determine many local weather parameters including atmospheric instability, freezing levels, wind shear, precipitation and icing potential.

Wallops is continuously rated by NWS in the top ten best-performing sites in the United States, and the RRS Program has been ranked number one in station performance of all 92 stations since the NWS began keeping records. This synergistic NASA-NWS relationship provides benefits for both agencies. The NWS benefits by having RRS' highly trained meteorological staff support their launch operations and weather research missions. NASA reaps benefits from this



Ben Robbins, RRS meteorology technician, releases a weather balloon that collects atmospheric data

relationship by having access to more than 40 years of locally archived climatology data used by numerous range customers to determine mission suitability and range availability.

For more information: Rob Hurley, robert.k.hurley@nasa.gov

UAS Hurricane

Wallops was the site of a significant first on November 2, 2007, when the RRS meteorological staff assisted with the launch of the first-ever flight of a UAS into the inner core of a hurricane as Hurricane Noel formed near the Bahamas.

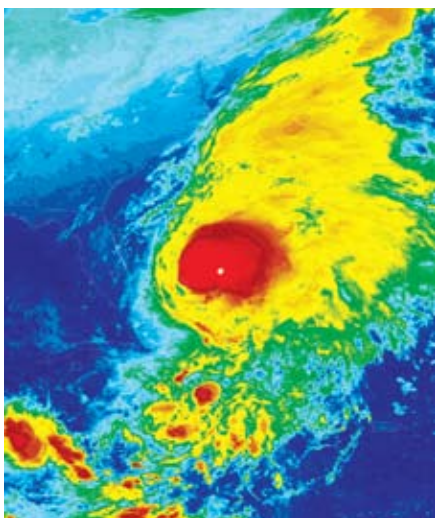


The Aerosonde UAS

Center using an Iridium satellite link between the UAS and the Wallops UAS Control Center. The use of this safer means of gathering very important weather data has the potential to improve hurricane preparedness and more importantly, save lives.

For more information: David Easmunt, david.p.easmunt@nasa.gov

The environment where the atmosphere meets the sea surface is extremely important in hurricanes, where energy from the ocean's warm water is transferred directly to the atmosphere. The hurricane/ocean interface is also where the strongest winds in a hurricane are often



Hurricane Noel Imagery

found. Observing and ultimately better understanding this region is crucial to improving forecasts of hurricane intensity and structure.

Although satellite data have revolutionized meteorologists' ability to detect early signs of tropical cyclones

before they form, they can-

not provide accurate wind speed information, nor can they provide the interior barometric pressure within a hurricane. These data are needed to accurately predict hurricane development and movement, and the use of aircraft better known as "Hurricane Hunters" have become routine in recent years but not without remaining a very dangerous mission. Thus, NASA and NOAA saw the opportunity to use a small, remotely piloted aircraft to retrieve a valuable new set of observations for air-sea interaction and tropical cyclone research.

During the flight into Hurricane Noel, the UAS flew in winds reaching 80 miles per hour in the core of the storm for approximately 7.5 hours, providing unique real-time detailed observations near the ocean's surface to NOAA forecasters at the National Hurricane

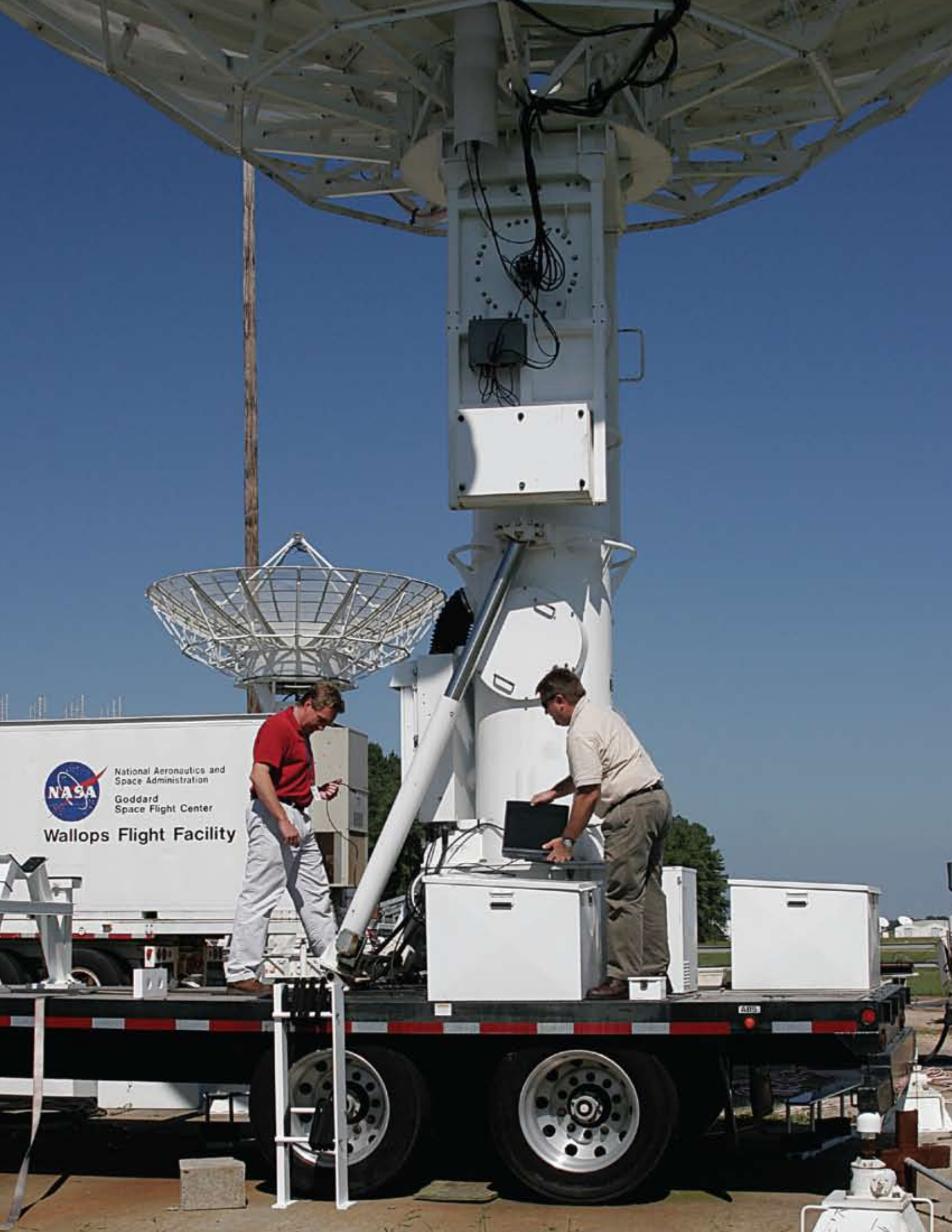
Runway Friction

Tire wear is a major economic concern to commercial and military aviation since tire replacement accounts for approximately half of the overall landing gear maintenance cost of jet aircraft. Since 1978, NASA and the Federal Aviation Administration (FAA) have conducted experiments to measure and evaluate tire and surface friction performance under a variety of adverse weather conditions. Results of this research have been leveraged in the design of Space Shuttle tires as well as in the design of tires for military and commercial use.

As part of the annual NASA/FAA Runway Friction Workshop, which has been hosted continuously by Wallops for the past 15 years, tests are performed using NASA test equipment, FAA test equipment and several industry devices that take advantage of any combination of the 13 concrete and asphalt test surfaces available on the WFF Research Airport. The workshop provides not only an opportunity to add to the tire/pavement friction database but also provides a better understanding of how pavement texture and roughness influence the tire/pavement interface. The research also supports ongoing studies to explore how interactions between tires and pavement surface conditions affect safety of air travel in adverse weather conditions.

At this year's workshop in May 2008, nearly 100 participants from 15 countries convened to discuss friction monitoring, testing and procedures. Research Range Services personnel provided project support, meteorological support and photo/video coverage.

For more information: Rob Hurley, robert.k.burley@nasa.gov ■



National Aeronautics and
Space Administration

Goddard
Space Flight Center

Wallops Flight Facility

◀ Ron Taylor and Don Penney, RRS hardware engineers, perform a routine engineering evaluation of the RRS mobile radar assets

◀ Kevin Downing, RRS radar technician, performs maintenance and testing on the Air Surveillance Radar-7



Program Modernization

To accommodate current and future needs of a diverse customer set, the RRS Program not only continuously performs ongoing preventive and corrective maintenance but also collaborates with other NASA organizations and external agencies to pursue engineering and technology improvement projects to ensure readiness, enable the evolution of space-based metric tracking, telemetry and command relay architecture and avoid equipment/system obsolescence.

In order to manage the obsolescence issue, RRS staff embarked on a systematic review and assessment of all major RRS subsystems. This review identified those subsystems in most need of sustaining engineering or replacement. The resulting “State of Health,” developed with the support of RRS government and contract engineers, is shown in Figure 1. Using this information as a guide for investment, the RRS Program has deployed scarce dollars into those subsystems whose failure seems more imminent or more impacting to expected NASA missions. In addition, the WFF Range and Mission Management Office provided additional funding and support for key efforts in order to maximize the impact of required maintenance and upgrades. Technology efforts, where needed, were funded from non-RRS funds per SMD guidance to the RRS Program Manager.

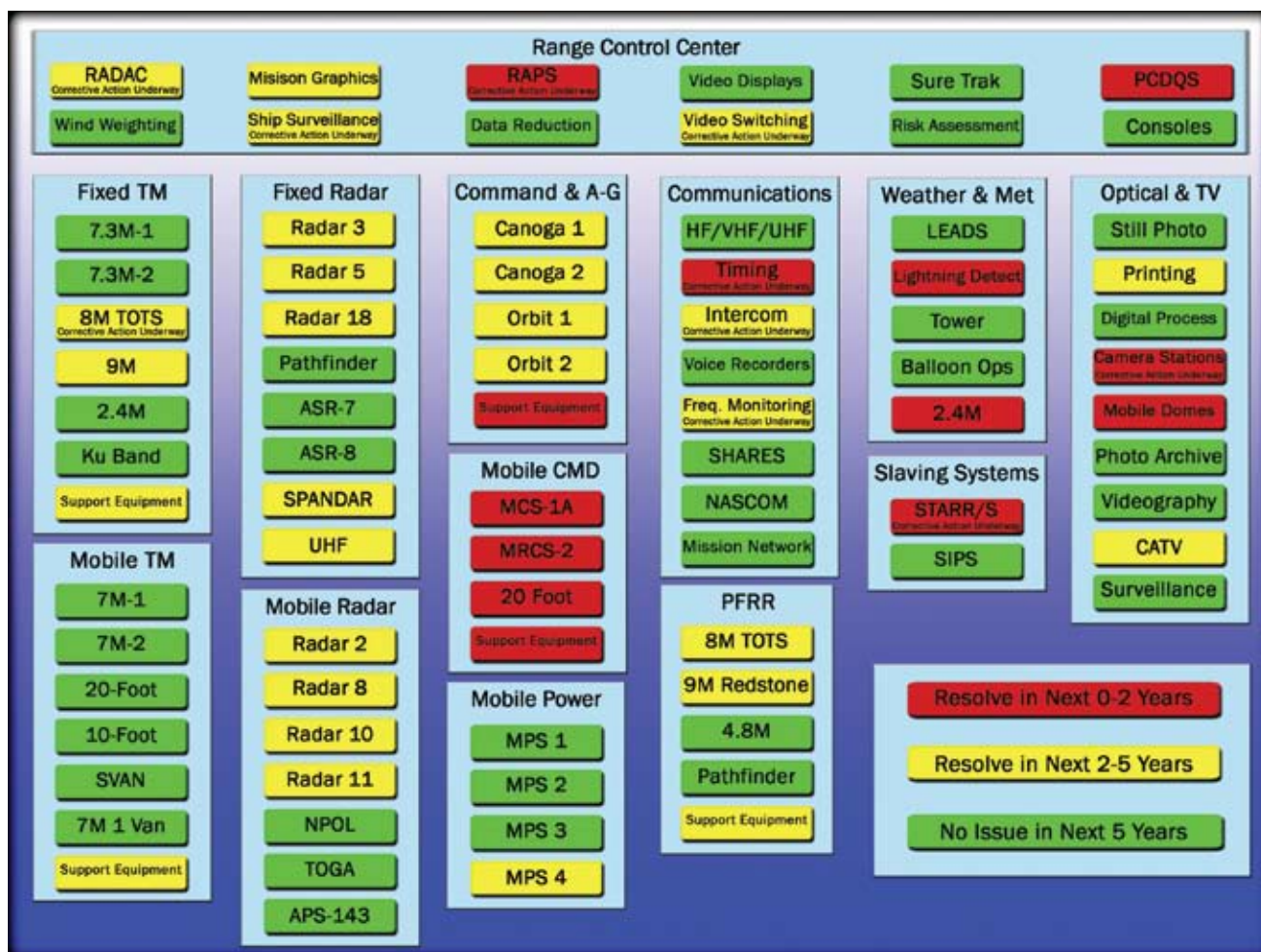


Figure 1: RRS Program State of Health

Research Range Services Program Modernization during FY 2008 focused on **Technology Infusion** to add new capabilities, **Technology Refresh** to sustain critical capabilities or extend the life cycle of key assets and modifications to improve **Information System Security**.

For more information: Steven Kremer, steven.e.kremer@nasa.gov

Technology Infusion

Technology infusion is the process of strategically binding technical needs and potential solutions to efficiently and effectively support customers. During FY 2008, RRS technology infusion projects increased capabilities in support of NASA's programs and contributed to the goal of continually modernizing the RRS

facilities and processes through advanced technology in hardware upgrades and new or improved software.

- **Mission Planning Lab (MPL):** A variety of customers require RRS fixed and mobile ground systems to be uniquely configured, and often these customers are unaware of the implications these modifications have on operations and certain test articles or how their plans fit with RRS constraints. To assess critical mission concept areas quickly for technical feasibility, safety and cost, the RRS Program established the MPL. The MPL helps customers weigh their launch decisions quickly and confidently by providing a collaborative analysis tool that produces realistic simulations and presentations to assist in evaluating choices about platform selection, flight profiles and range-asset placement. For pre- and post-flight mission support,



▲ Sarah Daugherty, RRS software engineer, inspects an MPL video production for accuracy

the MPL visualizes, analyzes and optimizes mission specifications based on vehicle characteristics, range setup and performance to support missions using a four-phase assessment process that answers the following questions:

Visibility: how will the mission look and/or how did it look?

Feasibility: can the mission be done?

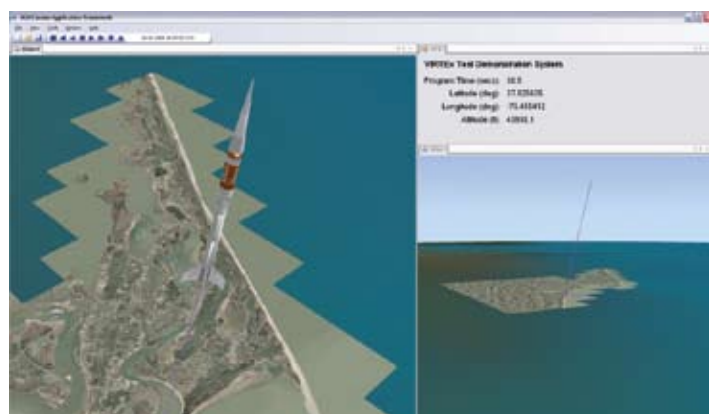
Variability: what mission parameters can/should be optimized?

Certainty: how correct are the MPL simulation data?

The MPL capabilities developed at Wallops are now routinely used by customers to reduce risk and optimize mission coverage. Additional ongoing efforts will dramatically reduce the time required by RRS operations staff to perform mission planning functions such as link analysis and range instrumentation support approaches.

- **Visualization in Real-Time Experiment (VIRTEx):**

The RRS staff expanded on the success of the MPL to depict real-time information and provide a “fly-as-tested” representation of



▲ VIRTEx Screen Shot

mission launch and flight events. The VIRTEx display supplements the existing graphics display system information with a three-dimensional view not readily captured by cameras nor depicted by other means in the RCC. VIRTEx is designed to display with 3D graphics the attitude and position of the launch vehicle and payload during flight. Two windows are used in the application display; one window is zoomed-in on the vehicle in order to see the attitude and stage separation events, and the other window includes a perspective from farther away to see the trajectory path. Such a display is useful to safety and mission analysts in assessing the performance of a launch vehicle in real time.

- **Selectable Internet Protocol Slaving (SIPS) system:**

Slaving is an essential launch range capability that enables radar and telemetry antennas to share real-time target position data to expedite acquisition and tracking of the target by all antennas. Currently, more than 20 different slaving systems exist at Wallops. The SIPS system is a flexible, comprehensive, real-time system using network-based communications to provide slaving for antennas that do not currently have this capability while also replacing existing non-maintainable slaving systems. As a generic slaving system with a library of antenna controller drivers, SIPS can be used with any antenna when the appropriate driver is configured. The current Radar Auxiliary Processing System (RAPS) used by the RRS staff is more than 15 years old and needs replacing, so a new system is being deployed that is based on a scaled down and specially configured version of SIPS. This SIPS RAPS will provide radars with a real-time data stream of a wind-weighted nominal launch trajectory, and if needed, a radar may slave to this data stream to aid in target acquisition.

- **SureTrak Upgrade:**

SureTrak is a multi-sensor waterway and air surveillance system being used by RRS personnel to develop a sensor interface with ship surveillance radar and an interface to an application that calculates the probability of launch vehicle debris impacting ocean vessels. Ultimately, the SureTrak development will result in a safety-critical control center system for evaluation-of-risk prior to rocket launches.

• **RCC Interfaces (RCC I/F):** This project documents data interfaces between the systems that provide operational support to the RRS Program by providing a high level narrative of the functionality of each system. This enables users to drill down into each system diagram for more details and quickly and clearly identifies the across-the-range impact of a system change or failure. Future RCC I/F developments will include the capability to provide data formatting details and user interface documentation.

• **Wind Weighting Remote Capability:** Research Range Services engineers increased the volume and capability of support to NASA Sounding Rocket missions that use meteorological balloons by certifying the RRS-developed Wind Weighting Version 6.1 software. This software provides plots of launcher settings and has the ability to support multiple simultaneous meteorological balloons using any combination of GPS and radar tracking data. Data from multiple balloons contribute to the same wind table, and this software decreases the necessary tracking time, saving personnel costs and increasing data freshness. This capability provides more than the usual radar-measured wind speed, direction and position; the sensors also provide temperature, humidity, dew point, speed of sound and other environmental parameters. Wind Weighting's ability to receive GPS data from rising balloons will be further upgraded to a newer Windows operating system in August 2009.

• **Risk and Toxic Blast Analysis Support:** In order to provide in-house risk and toxic blast analysis support, RRS engineers developed internal processes, provided training to range safety personnel and established a Risk Assessment Center (RAC). Using the RAC, safety analysts now have the capability to plan safe operations by analyzing potential threats to populations that could arise if winds were to carry fumes from rocket fuels or if there were propellant releases or blast pressures in the event of a launch failure.

• **Ku-Band Antenna and Ground Station System:** In an effort to establish a new capability to support high data rate telemetry using the Ku-band, RRS engineers collaborated with other WFF engineers to implement a Ku-band antenna and ground station system.



Karen Clark and Ron Taylor, RRS hardware engineers, collect Ku-band data during the NGSP mission

The RRS engineers participated in the design, procurement, testing, flight operations and post-flight analysis phases of the mission, and this successful demonstration increased the available options to receive telemetry data at a ground station utilizing the available Ku-band antenna.

• **Remotely Controlled Radar Operation:** In July 2008, RRS engineers incorporated the capability to provide increased mission support while still operating in concert with safety considerations by developing a radar remote control capability that permits operating the system from outside the launch hazard area. This capability further increases the availability of the radar for mission support, since it can now be operated if personnel are required to evacuate the hazard area.

• **Communications Coverage Enhancement:** Research Range Services engineers designed a new capability that extends the line of sight for the Marine Band communications for ship surveillance from nine miles to a range of approximately 30 miles. Formerly, the

RCC could only provide a minimum capability to clear the launch hazard area and provide direction to the recovery vessel. This improvement in voice communications provides earlier warning to ships and provides more time to respond so surveillance operations staff can avoid or clear the hazard area. This upgrade also included an additional antenna and radio that can be used as a backup or separate frequency channel.

- **Leading Environmental and Display System (LEADS):**

Traditionally, weather forecasters archive written information regarding climate data that includes only temperature and precipitation, but in order to make accurate decisions on launch windows, scientists or experimenters need additional environmental information such as lightning, winds and temperature. Previously these data were purchased by the RRS Program from the National Climatic Data Center. In response to frequent customer requests for climate data, RRS engineers developed a new archive capability by initiating the hardware installation and factory acceptance testing of LEADS to allow access to environmental data without having to purchase them from an outside source.

- **Mission Operations Voice Enhancement (MOVE):** In support of a NASA Headquarters initiative to increase commonality across NASA Centers, RRS engineers provided critical support early in the project life-cycle of the commercial off-the-shelf MOVE system planned to be supportable for the next 15 to 20 years. MOVE is a multi-location implementation of a mission voice intercom replacement, and each Center must provide its own design and integration plan. Research Range Services personnel successfully completed the preliminary design review and participated in technical interchanges and testing to eventually replace the three current obsolete communications systems used by the RRS Program with a single MOVE system.

Technology Refresh

Throughout FY 2008, the RRS engineering team continued to assess range obsolescence and then upgraded or replaced RRS instrumentation to ensure systems reliability. The team continues to pursue opportunities for technology refresh improvements and evaluate effects of technology infusion as ongoing requirements and changing customer expectations demand.

- **Air Traffic Control (ATC) Support:** Research Range Services engineers have implemented improvements to equipment and associated processes to increase their support capacity to the controllers. Previous voice recorder systems could not record voice data from two sources. To accommodate this shortfall, some of the data had to be recorded using shared network equipment. Engineers from RRS installed a new voice recorder in the ATC Tower and upgraded the NASCOM voice recorder by adding 24 channels, network tim-



Dean Morris, RRS Photo/Optical Lab technician, performs preventive maintenance on television satellite receiving systems at Wallops

ing interfaces and all associated computer equipment and cabling, making it possible to meet ATC recording capacity requirements without relying on shared high-risk assets. This upgrade also improved ATC safety by eliminating communication outages.

• **Camera Improvements:** To enhance services to WFF Public Affairs and to ensure security compliance, RRS engineers increased technical performance of the cameras used on the Range by replacing camera mounts that had been susceptible to excessive movement during windy conditions. The new mounts utilize a tri-pod base with

from a flight vehicle and then displays both hazard areas associated with a launch and the nominal trajectory planned for flight. It also provides IIP results along with data needed to determine flight safety. The RADAC provides statistics for making data quality decisions, archives launch and flight information and contains tools needed for post-flight data reduction. In December 2007, RRS engineers completed replacement of the obsolete legacy RADAC and removed the old equipment from the RCC. In August 2008, the RRS Program developed, installed and began testing computer code to port the new RADAC's custom software to a Linux-based PC. When this replacement project is completed in 2009, proprietary computers will be removed, resulting in reduced maintenance costs.

• **Telemetry Processors (TelPros):** Research Range Services engineers developed an approach to extend the life cycle of existing TelPros by migrating the hardware from obsolete DOS-based PCs to Windows PCs. The hardware upgrade was accomplished at minimal cost by re-using PC boards from the original DOS PCs. The new TelPros are scheduled to transition to operations in mid-2009. These improved systems will alleviate severe maintenance and obsolescence concerns associated with these critical systems which process all Range telemetry data at Wallops.



▲ Bill Dize, RRS radar technician, operates Radar 5 during RRS operations

a wider stance that adds improved stability. Video surveillance is an important element of security and Public Affairs for launch coverage, and this seemingly small improvement has potential critical impact. RRS engineers will continue to perform follow-up camera improvement work in FY 2009.

• **Instantaneous Impact Prediction (IIP) Modifications:** Research Range Services engineers modified the RRS-developed IIP software to improve the capability and safety of mission support at remote sites. This enhances safety by providing a better prediction of the impact point of a vehicle based on its real-time trajectory. It is particularly important when launching at sites away from WFF because those sites often do not have the same capabilities to receive GPS and radar data simultaneously or to provide impact prediction solutions using both data sources.

• **Radar Data Acquisition Computer (RADAC) Upgrade:** The RADAC receives radar tracking and telemetry data



▲ Zach Dornhagen, RRS radar technician, performs routine maintenance on radar components



▶ Katie Ford, RRS software engineer, operates the RADAC system during mission operations

Information System Security

In today's global Internet connectivity environment, government facilities and equipment must continue to meet and maintain information system security requirements. As with several initiatives this year, RRS engineers reviewed requirements, regulations and procedures to ensure RRS systems used best practices to continue to fulfill Information System Security responsibilities to NASA and other customers.

- **Contingency Planning:** NASA's Information Technology (IT) security requirements, adopted in 2007, drove process changes to Range operations, including the need to verify security controls through annual testing and by using the IT security information archival system for reporting. During FY 2008, RRS engineers completed on-time successful contingency plan testing for all five RRS information systems.

- **National Institute of Standards and Technology (NIST) Procedures:** Research Range Services engineers developed a local operating procedure for the mission network to ensure NIST 800-53 controls were maintained. This new process ensured security controls remained in place or were put in place when systems were reconfigured or modified or when new systems were added to the RRS Program. These requirements have added new security procedures

such as reviewing log files to detect potential system intrusion incidents and conducting performance monitoring.

- **Network Time Protocol Server (NTPS) Synchronization:** To facilitate meeting IT security requirements, RRS engineers implemented NTPS synchronization for all RRS networked systems. This ensured that all logged data were synchronized to enable time accuracy should an investigation be required for a launch failure or security system incident.

- **Command Destruct System Certification:** Research Range Services IT Security professionals successfully completed certification documentation for the Command Destruct System and supported a third-party security test and evaluation audit. Based on results of the audit, the third-party official recommended an Authority to Operate certificate be issued for the system to keep the RRS Program compliant with IT regulations.

- **Secure Data Gateway:** Research Range Services engineers completed the development, installation, configuration scripting and testing of a secure data gateway for the mission network, allowing delivery of data to external customers without exposing the network to electronic intrusion from the Internet. ■

Outreach and Education

Fiscal Year 2008 proved to be an active, effective and rewarding year for RRS outreach and education efforts, with staff members continuing the rich tradition of being involved in their local communities and beyond to support NASA's mission to attract, educate and encourage future explorers to the wonders of space exploration.

To encourage young people to pursue careers in science and engineering, RRS personnel provided weekly interactive tours to primary and secondary school students and to participants in scouting groups and space camps. During these tours, RCC employees hosted students as they played various technical support-staff roles such as Test Director, Program Timer, Range Safety Officer and various technicians in a simulated re-enactment of a rocket launch.

Research Range Services staff also enthusiastically responded to requests for interviews and questionnaires from a number of local university students which provided them with unique and enlightening insights into the RRS Program and the NASA science missions. ■



◀ Jimmy Holloway, RRS data quality operator, walks students through a launch re-enactment at the RCC

Air traffic control tower in the early morning at WFF ▶





RRS operates and maintains a number of radar and telemetry systems at Poker Flat Research Range near Fairbanks, Alaska

Looking Ahead to FY 2009 and Beyond

The future is bright with opportunities as the RRS Program continues to offer NASA, DoD, other federal agencies, commercial space corporations and other customers the most comprehensive suite of range instrumentation for tracking, telemetry, command and optical coverage. With the capability to support users requiring concurrent operations with dedicated instrumentation for each flight vehicle, redundant range instrumentation coverage and information assurance, a variety of viewing angles for optical instruments and flexibility and adaptability through use of deployable mobile assets, the RRS staff has a reputation of always being prepared for each mission. With a low-turnover ratio and many RRS personnel working with the same equipment in excess of 10 years, the staff has an unparalleled ability to quickly fix problems, respond to instrumentation performance issues in real time and achieve high reliability in capturing data.

The RRS Program supports aurora research at many remote locations including Poker Flat Research Range



Looking ahead to FY 2009, the RRS Program is planning for several exciting opportunities to provide support for a variety of science, exploration, defense and commercial launches including the Poker Sounding Rocket Campaign, the Max Launch Abort System (MLAS) test program, the Ares 1-X and 1-Y test and flight demonstration launches, the Lunar Atmosphere and Dust Environment Explorer (LADEE) project, the Air Force's TacSat-3 orbital mission and the Taurus II facility build up. Program modernization efforts will continue as well to ensure RRS equipment and facilities are maintained and updated with the latest available technology.

Poker Sounding Rocket Campaign

Research Range Services personnel will use mobile range assets to facilitate eight launches in 2009 and three launches in 2010 from Poker Flat Research Range outside Fairbanks, Alaska, in support of NASA's Sounding Rocket Program.

To support these launches, RRS personnel already performed significant preparation work on the mobile range assets at WFF in October 2008, and then transported the assets to Alaska by barge in early November. Following setup and verification of operation, RRS crews will return to PFRR to support the sounding rocket launches in January and February 2009.



Poker Flat Research Range during a previous sounding rocket campaign

Research Range Services personnel will staff four Poker Flat telemetry antennas and provide use of the RRS mobile telemetry antenna for these missions, providing telemetry tracking and data reception, recording, processing and displays. Personnel will also check out and operate radar systems to provide tracking data on the sounding rockets during flight, collect wind and weather measurements during the pre-launch preparations and provide timing and voice communications systems to ensure telemetry and radar assets are slaved together for coordinated support. The RRS Program will perform similar roles in support of the sounding rocket missions planned for 2010.

The science missions to be carried into space aboard these sounding rocket campaign launches include:

- **Ionospheric Science and Inertial Sensing:** to measure the plasma and geomagnetic structures of the D-region of the Earth's ionosphere as well as ozone density at lower altitudes in a high latitude region.
- **Aurora Current and Electrodynamics Structure:** to study the geometry and various electric fields and current structures within a stable aurora arc.
- **Changing Aurora in-situ and Camera Analyses of Dynamic Electron Precipitation Structure:** to investigate the motions and structures associated with electron precipitation in a discrete aurora and low frequency electric field activity in the Earth's ionosphere.
- **Turbopause:** to identify the uppermost levels of neutral air turbulence in the Earth's atmosphere by observing the dispersion of a tracer chemical from sounding rocket payloads and by direct measurements of electron densities and small-scale fluctuations in neutral air in the upper atmosphere.
- **Correlation of High-Frequencies and Auroral Roar Measurements-2:** to answer several questions about the physics of high-frequency waves in the Earth's aurora by using instruments aboard the sounding rocket payload to measure rapid oscillations of the electron density in the plasma in Earth's upper atmosphere and correlate them with auroral electrons of various energies.
- **Polar Night Nitric Oxide:** to measure the concentration of nitric oxide in the mesosphere and lower thermosphere in the nighttime polar region, where energetic electrons in the aurora split nitrogen molecules in two and where peak concentrations can be measured in the absence of sunlight.
- **Trimethyl Aluminum Ampule:** to explore the origins and consequences of small wind gradients in Earth's auroral thermosphere while testing a new approach using one sounding rocket payload to deploy multiple sets of chemical tracers at multiple altitudes as the rocket ascends.

For more information: *Gerald Vieira, gerald.j.vieira@nasa.gov*

Max Launch Abort System (MLAS)

Project Support

Wallops has been selected by NASA's Exploration Systems Mission Directorate and Engineering and Safety Center as the lead range and launch site for assembling, integrating and operationally testing an experimental launch abort system for the new Ares 1 Crew Launch Vehicle (CLV).

MLAS is a simpler design compared to the already-in-development Launch Abort System (LAS) in that it has no active guidance and utilizes normal-flow abort motors mated around the crew module. WFF was selected for this proof-of-concept test based on past launch abort testing experience and non-involvement in the current LAS testing to ensure both systems are developed independently.



Jacob Owen, RRS Photo/Optical Section technician, videotapes the MLAS fabrication process

The test launch in Spring 2009 will evaluate the flight stability of the MLAS and its ability to deploy orientation parachutes, reorient itself, jettison the fairing and land safely downrange from the launch site. Upon successful completion of this proof-of-concept, additional launches may be scheduled.

The RRS Program has already supported the project during a motor igniter test with high-speed photography, range timing and

communications, and the RRS staff is currently documenting the assembly and integration of the MLAS test article using three fixed cameras. A time-lapse video will be produced using images from the cameras, and a dedicated telemetry system will be set up on the Wallops mainland to serve as an alternate blockhouse facility housing the launch control circuits and additional project telemetry resources. During launch, the dedicated telemetry system will receive the four MLAS links with help from the 2.4-meter Low Gain Telemetry Antenna System antennas. Research Range Services radars will also track the vehicle during the launch, throughout the 1.5-minute flight and during decent. High-speed and standard-speed video along with aerial photography will also capture data during the flight.

For more information: Jeff Reddish, jeffrey.a.reddish@nasa.gov

Ares 1-X and 1-Y

The RRS Program's telemetry support architecture solution study, now in its design phase, was approved by NASA to investigate reliable low-cost solutions for tracking Ares 1, NASA's next-generation spacecraft and launch vehicle system scheduled for test launching in 2009. The first test flight, Ares 1-X, will bring NASA one step closer to its exploration goals to return to the moon for more ambitious exploration of the lunar surface and to travel to Mars and destinations beyond. The flight will provide NASA an early opportunity to test and prove hardware, facilities and ground operations associated with the Ares 1 CLV and will allow the gathering of critical data during ascent of the integrated Orion crew exploration vehicle and the Ares 1 launch vehicle stack, data that will ensure the vehicle system as a whole is safe and fully operational before astronauts begin traveling into orbit.

Research Range Services personnel are examining both direct and skip-entry trajectories and are considering various platform and location alternatives to provide independent entry tracking including airborne, ship-based and land-based platforms. The RRS solution provides independent tracking to monitor the position and velocity

of Orion during entry and protects against intermittent or total loss of communications with the vehicle or corruption of data from the on-board navigation system. It utilizes available ground station hardware employed for sounding rocket operations but with equipment mounted in mobile racks instead of trailers. The equipment rack concept was successfully demonstrated during sounding rocket campaigns in Norway, and the specialized quadrature phase-shift keying



▲ Adrian Justis, Telemetry Receiving technician, makes adjustments to a rack system

bit sync equipment will be tested and integrated by RRS staff at WFF and Cape Canaveral telemetry stations prior to launch.

Research Range Services technicians will be on site during the Ares 1-X launch to operate the equipment and provide vehicle performance video. The RRS Program will also support the subsequent Ares 1-Y developmental flight scheduled for 2012 or 2013.

For more information: Jeff Reddish, jeffrey.a.reddish@nasa.gov

Lunar Atmosphere and Dust Environment Explorer (LADEE)

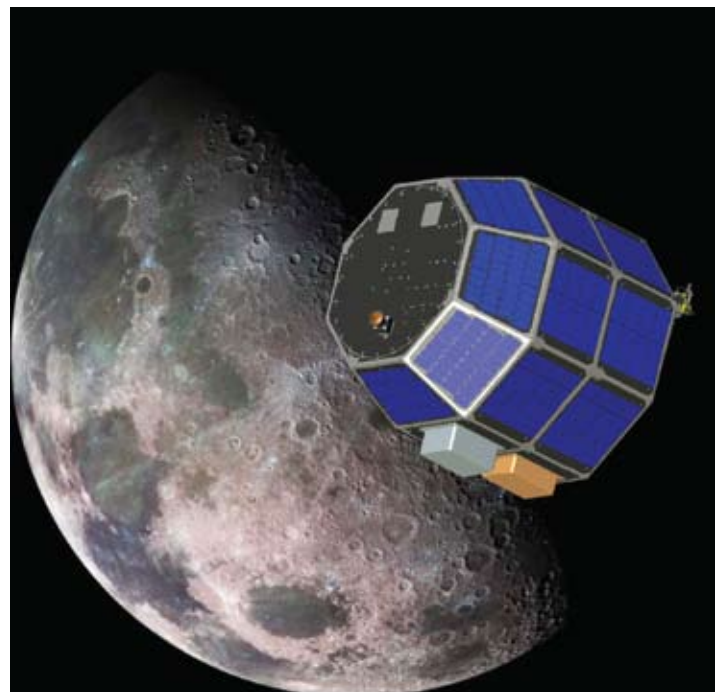
In one of NASA's first missions returning to the moon, LADEE will fly from WFF on the new 5-stage Minotaur V rocket. The spacecraft and payload, developed by Ames Research Center and GSFC, will orbit the moon and provide data on the scarce lunar atmosphere and its dusty environment.

The payload will include:

- Dust Detector instrument to detect impinging dust particles over an aperture of approximately 150 square centimeters and measure particles down to 0.2 microns.
- Neutral Mass Spectrometer instrument to detect helium, argon, methane and other species either released from the deep lunar interior or from the surface of the moon.
- Ultraviolet/Visible Spectrometer instrument to measure the lunar atmosphere and to measure limb dust by calculating backscattered or forward scattered sunlight.
- Lunar Laser Communications Demonstration to exhibit a high bandwidth space-to-ground link using a reliable optical terminal to show sub-centimeter ranging for navigation and characterization of atmospheric propagation data.

With LADEE, the RRS Program will build on its successes with past Minotaur launches and provide reliable low-cost launch support services including the RCC, meteorology services, tracking cameras and video systems, communications and timing, fixed telemetry, fixed radar and airborne and surface surveillance radar.

For more information: Doug Voss, douglas.g.voss@nasa.gov



▲ Artist's Conception of LADEE

TacSat-3

In Winter 2009, the RRS Program will support its third Minotaur launch into orbit from the Mid-Atlantic Regional Spaceport for the Air Force Research Lab's TacSat-3 mission. The Minotaur 1 is a four-stage vehicle developed for the Air Force and consists of government-supplied Minuteman II stages plus other stages developed by Orbital Sciences Corporation (OSC). Objectives of the TacSat-3 mission include showing the rapid design, construction, integration and test of a launch-ready space vehicle; demonstrating responsive launch operations within seven days of alert and providing real-time data collected from space to combatant commanders in the field.

The TacSat-3 payload includes the Advanced Responsive Tactically Effective Military Imaging Spectrometer hyperspectral imager, the Ocean Data Telemetry Microsatellite Link, the Space Avionics Experiment, a PharmaSat-1 Picosatellite and three other picosatellites as part of the CubeSat Technology Demonstration Project. The picosatellites are from NASA's Ames Research Center, the Aerospace Corporation, and the Hawk Institute for Space Studies.

The RRS staff will provide tracking, telemetry data collection and pre-flight and flight control during the operation. The staff will also coordinate and provide use of authorized operating space for the ascent to orbit and provide use of a frequency spectrum to enable the launch vehicle and payload to transmit data to the ground. Additional RRS support for this mission will include instrumentation at two downrange sites and the coordination of flight vehicle and payload operations through the RCC during countdown, launch and flight.

Benefits to NASA of supporting the Air Force TacSat program have been numerous. In addition to reimbursement for the RRS Program and other Range services, NASA has obtained key understandings of the Minotaur launch vehicle and more than \$2 Million in ground support equipment. These benefits have allowed NASA to consider the use of these surplus launch vehicles for science missions.

For more information: *Gerald Vieira, gerald.j.vieira@nasa.gov*



▲ Minotaur 1 on Mid-Atlantic Regional Spaceport launch pad at Wallops Island

Taurus II

Through collaboration with the State of Virginia and the Mid-Atlantic Regional Spaceport, OSC has selected WFF as its base of operations for the company's new Taurus II rocket.

With the Taurus II vehicle, OSC is a potential supplier to NASA for the ISS Commercial Re-supply Services Contract as well as other NASA missions. It will be the largest rocket ever launched from WFF and has the capacity to deliver more than six tons to low earth orbit.

Over the next two years, both commercial and Virginia state funding will be invested in WFF to develop launch site infrastructure that will include a launch complex, processing facility and liquid fueling facility to support assembly, test and launch of the Taurus II space launch vehicle and other future space launch vehicles.

The first demonstration launch of the Taurus II vehicle is scheduled for December 2010, when it will carry an un-pressurized cargo container to low earth orbit and demonstrate proximity maneuvering capabilities for future ISS re-supply dockings. Upon successful completion of the demonstration launch, multiple Taurus II launches per year are anticipated from the WFF. The RRS

Program will be especially critical in support of the

◀ Taurus II Artist's Conception
(actual dimensions: 40 meters
high by 3.9 meters diameter)

Taurus II program, providing tracking, telemetry and command services and range requirements tracking for the demonstration launch and future launches.

For more information: Jeff Reddish,
jeffrey.a.reddish@nasa.gov

Future Program Modernization

Several modernization projects from FY 2008 will continue to be refined and deployed in FY 2009, and several additional projects will begin. Each of these modernization projects is needed to ensure critical capabilities for RRS support to NASA missions, and each will enable resources to shift from maintaining older systems and equipment to supporting new

technology. Fortunately, maintenance of the older systems has not yet negatively impacted launch capabilities, but upgrades and replacement are necessary to continue the high quality of launch support historically provided by RRS. As the launch schedule continues to grow, newer operating systems and equipment will provide the efficiency and reliability necessary to meet increased customer demands.

- An old mobile camera mount will be refurbished and an Antenna Control Unit will be added to allow a camera to track a target and provide slaving data to other

tracking assets. Utilizing a camera as a slaving source will replace a fully manual acquisition methodology with semi-automated capabilities. Completion is expected in 2009.

- Upgrade of the 8-meter telemetry system is planned for the first half of 2009. The upgrade will ensure maintainability and improve tracking reliability as well as provide a higher performance telemetry system for Wallops. Completion is expected in early 2009.
- A new timing system is expected to be installed in mid- to late-summer 2009 to replace the existing timing system which is currently operating at extremely high risk due to parts unavailability.
- A new mission graphics system will provide a visual display of safety limits and criteria along with real-time updates of vehicle position. NASA is pursuing this work with the collaboration of contractors for requirements and design ideas. Completion of this project is expected in 2010.

Funds to support these and other upgrades are partially obtained from non-NASA users whose requirements exceed the current funded baseline. In this way, all users improve the RRS Program and enjoy the benefits of these improvements.

For more information:

Steven Kremer, steven.e.kremer@nasa.gov ■

Abbreviation List

AMG	Advanced Modular Gun
AirSTAR	Airborne Sub-scale Transport Aircraft Research
ALV	ATK Launch Vehicle
ARR	Andoya Rocket Range
ATC	Air Traffic Control
CLV	Crew Launch Vehicle
DoD	Department of Defense
FAA	Federal Aviation Administration
GPS	Global Positioning Satellite
GSFC	Goddard Space Flight Center
GTM	Generic Transport Model
HyBOLT	Hypersonic Boundary Layer Transition
IIP	Instantaneous Impact Prediction
IT	Information Technology
ISS	International Space Station
LEADS	Leading Environmental and Display System
LADEE	Lunar Atmosphere and Dust Environment Explorer
LAS	Launch Abort System
Mpbs	Million Bits Per Second
MDA	Missile Defense Agency
MLAS	Max Launch Abort System
MOVE	Mission Operations Voice Enhancement
MPL	Mission Planning Lab
NASA	National Aeronautics and Space Administration
NASCOM	NASA Communications
NGSP	Next Generation Sensor Producibility
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NTPS	Network Time Protocol Server
NWS	National Weather Service
OSC	Orbital Sciences Corporation
PFRR	Poker Flat Research Range
RAC	Risk Assessment Center
RADAC	Radar Data Acquisition Computer
RAPS	Radar Auxiliary Processing System
RCC	Range Control Center
RRS	Research Range Services
SCIFER	Sounding of the Cusp Ion Fountain Energization Region
SIPS	Selectable Internal Protocol Slaving
SMD	Science Mission Directorate
SOAREX	Suborbital Aerodynamic Re-entry Experiments
Sub-TEC	Suborbital Technology Experiment Carrier
TRICE	Twin Rockets to Investigate Cusp Electrodynamics
TelPros	Telemetry Processors
UAS	Unmanned Aircraft System
VIRTE _x	Visualization in Real-Time Experiment
WFF	Wallops Flight Facility

National Aeronautics and Space Administration

Goddard Space Flight Center
Wallops Flight Facility
34200 Fulton Street
Wallops Island, VA 23337
www.nasa.gov/centers/wallops

www.nasa.gov